Using Gliders to Resolve Dynamics of Dust and Phytoplankton in the Mediterranean

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LONG-TERM GOALS

Optical properties are complex representing variable contributions of phytoplankton, Colored Dissolved Organic Matter (CDOM), marine and atmospherically derived non algal particles. The relative contributions of these are particularly complex for enclosed inland seas such as the Mediterranean. Results have shown that it is especially critical to collect regional ocean color data from satellites, which must be complemented with spatial subsurface measurements, which can be measured with the physical/optical sensor packages mounted on Webb gliders. We propose to use Webb Gliders to provide a regional subsurface physical and optical dataset to support ship-based NASA, NATO, and ONR efforts being conducted in the Mediterranean in late spring 2008 and early Autumn 2009. The Gliders will be used to map the subsurface features over monthly timescales and assess to what degree the non-algal particles are spatially and temporally correlated in space and time.

OBJECTIVES

Specific objectives of this research include the following:

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1) use several Webb Gliders to provide a regional subsurface physical and optical dataset to support ship-based NASA, NATO, and ONR efforts being conducted in the Mediterranean in late Fall 2008 and Spring 2009,

2) coordinate the activities of a fleet Gliders that are outfitted with a variety of sensors to quantify the physical hydrography of the coastal and offshore waters in the Mediterranean, the apparent and inherent optical properties, and a range of fluorescence measurements,

3) demonstrate a web-based Glider Operation Center for Gliders with fleet control being transferred between operators on the ship, personnel at the NATO facility at La Spezia, and scientists & students in United States throughout the 2-month long experiment and,

4) use the data to understand physical and optical dynamics in the Mediterranean with a focus on understanding the relative importance of atmospherically derived sub-micron dust particles and phytoplankton to determining the derived satellite data products.

APPROACH

The research in the recent year consisted of the following tasks:

Task 1: We will use optically outfitted gliders to spatially map the upper water column optics prior to ship-based efforts in the Mediterranean. With ONR support a bio-optical glider has been developed. In collaboration with Michael Twardowski (WetLabs Inc.) and Clayton Jones (Webb Research Inc.), we have integrated the AUVB scattering sensor. These scattering sensors will be complemented with WetLabs pucks, which will provide the measurements of spectral backscatter. The pucks will also provide measurements of the fluorescence of Chlorophyll a (Chl a) and Colored Dissolved Organic Matter (CDOM) fluorescence. Finally the apparent optical measurements will be made with an upward OCR Satlantic multi-spectral radiometer. These measurements will provide a detailed picture of the in-water optics measurements. The gliders will be deployed one month prior to the ship cruise and provide near real-time data back support shore side planning prior to the cruise.

Task 2: Partake in NATO, ONR, and NASA efforts to calibrate the remote sensing reflectance of the international constellation of the ocean color satellites. Efforts will focus on using the multiple Gliders to map full satellite pixels to complement detailed ship-based measurements of the in-water optical properties. The Gliders deployed prior to the cruise will be recovered and new batteries will be installed prior to the cruise. The gliders will then be deployed from the ship during each of the cruise's master stations and the gliders will fly a spatial map that spans a full satellite pixel over the course of several days.

Task 3: Transfer the Rutgers Glider Operation Center (GOC) to the NATO SACLANT efforts. This transfer will be accompanied with Glider training. The transfer of the GOC will be transferred with Rutgers personel who will travel and deploy the infrastructure at the NATO base. The infrastructure will be tested during the Glider effort in the Fall 2008. The Glider training will be focused during a suite of formal classes that will be held both at Rutgers and at La Spezia. These training courses will include participates from NATO, NRL, Industry, and NAVO.

WORK COMPLETED

Glider training efforts were largely conducted in 2008. The second round of training will be conducted in spring 2010. Therefore efforts have largely focused on improving glider data availability. These efforts have focused on 1) making data available via OpenDap, 2) improve quality control with specific efforts focused on improving techniques for correcting the thermal lag impact on the glider salinity corrections, and 3) working with NATO personnel to improve the glider operations center.

Rutgers personnel participated in a cruise in the Mediterranean with NATO personnel in Spring 2009. The cruise was conducted throughout the European coastal zone spanning a wide optical gradient. The Rutgers team helped deploy gliders, coordinate the flight missions, and make continuous measurements using a ship-board flow through long pathlength capillary waveguide (LPCC). The LPCC was outfitted with a solenoid that moved a 0.2 micron filter in front of the flow through to allow measurements to be made for the total and dissolved hyperspectal absorption.

RESULTS

The Gliders were deployed several times during the 2009 field effort. During those efforts in February 2009 two gliders were deployed. The data flowed directly into the NATO Glider Operations Center and thus the main data sets were not transferred to the cool room. During field efforts, the two gliders transversed ~515 kilometers and collected close to 1600 vertical profiles of physical and optical data. The glider flight strategy was to keep the gliders close to the research vessel to collect spatial data to complement the shipboard diel sampling efforts. This strategy also provided the glider safety in these heavy ship traffic waters. The gliders were generally flown in cross-shore surveys (Figure 1) or where deployed for 9-18 (depending on the station) hour segments and then recovered the ship so could steam to next station. For the nine hour deployments the glider were programmed to profile for the upper 20 meters of the water column to maximize the number of profiles in the upper euphotic zone.

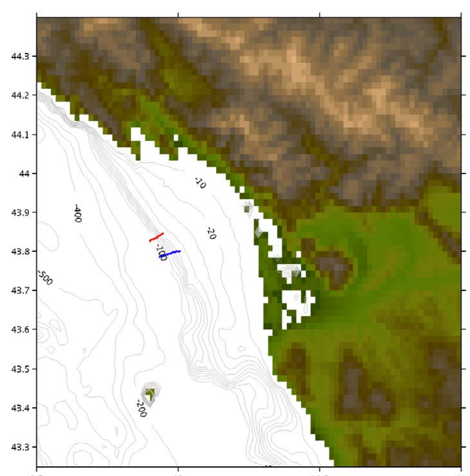

Figure 1. Flights of the Rutgers gliders in 2009. The red line is Rutgers glider RU16 and RU05 is the blue line. Sampling was focused at the shelf/slope boundary.

The gliders revealed a great deal of hydrographic complexity (Figure 2). The hydrographic complexity was seen in both gliders (Figure 3). Nearshore waters were characterized by low salinity water and had unique temperature structure. The variability in the temperature was not observed in the salinity fields. The variability seen in the temperature fields was mirrored with the chlorophyll fluorescence. In contrast, the CDOM patterns were consistent with the salinity data. Highest CDOM fluorescence was associated with the low salinity water.

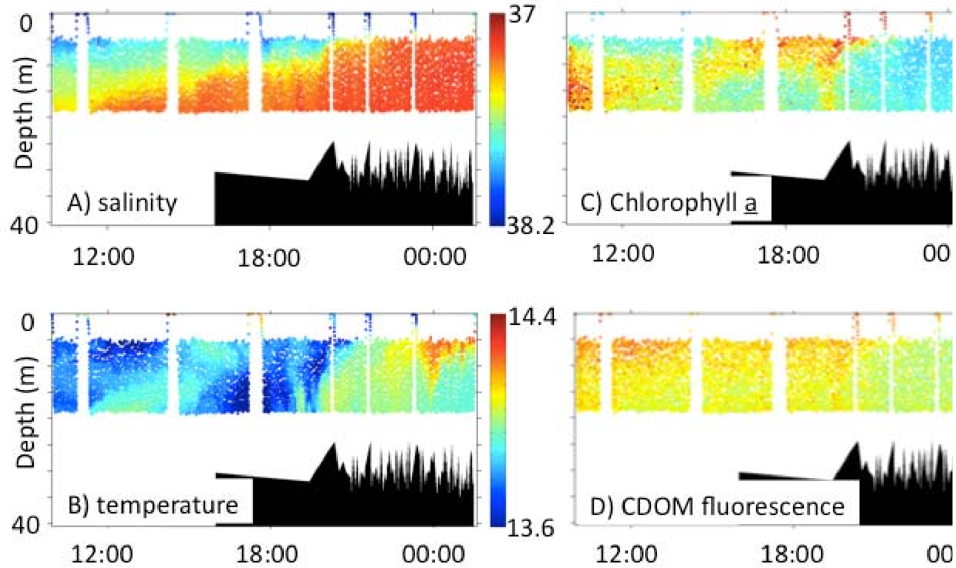

Figure 2. Physical and optical collected during the 2009 field season. During this 18-hour deployment, the gliders provided a spatial footprint in support of intensive ship board diel sampling.

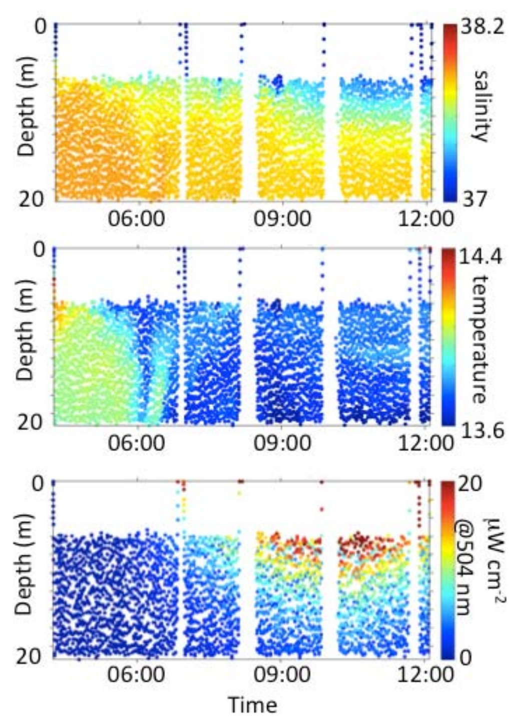

Figure 3. Data collected during a 9 hour deployment. The glider shows the sunrise and the associated increase in downwelling irradiance.

Data and glider control was successfully coordinated by the NATO GOC throughout the 2009 field program. The control of the gliders was also successfully transferred to the research vessel. This is a significant step forward from 2008 and it suggests the operational control of gliders has increased significantly. The confidence and experience base of military personnel is sufficient to now anchor field campaigns without the presence of “experts”. This experience is also borne out by numerous successful deployments by NAVO in 2009.

IMPACT/APPLICATIONS

The Navy’s mission has transitioned from a deep blue water tactical theatre to a littoral environment; however present Naval operational capabilities do not have the required data fidelity to deal with the complexity of coastal waters. These shortcomings are compounded as traditional sampling approaches are quickly compromised in denied access regions. The development of a long duration covert capability for collecting environmental (hydrographic and optical) data will offer a new paradigm in solving this problem. Using mine counter measures as an example, optical data would feed back on submersed and aircraft laser line scan mission planning by impacting the effective depth at which the laser can “see”. If the environmental characterization is performed over relevant scales the applications will assist real world missions, including mine detection and mine-counter measures, Special Forces operations, amphibious landings, shallow water anti-submarine warfare and force protection from terrorism.

RELATED PROJECTS

We have been actively collaborating with NATO Undersea Research Center and NAVOCEANO on this effort. All data is being freely shared. Discussion has been initiated how glider optical data might integrated into the ONR WOOD database. Data will be burned to data CD’s and will be made available via one-way FTP. Ongoing field efforts also distribute data in real-time over the world-wide web by Naval METOC
groups, NAVO, NOAA, and the European partners. The data will be distributed to fellow PIs. Developing the optical capability for gliders will directly benefit a recently funded Major University Research Initiative (MURI), which will develop a data assimilative physical-optical modeling/observation system consisting of an ensemble of optical models of varying complexity. This MURI will study the regulation of ocean color for a broad western boundary continental shelf with a specific focus on regions of high optical variability (fronts), which coincides with regions of high acoustic uncertainty.

PUBLICATIONS

No publications have been achieved yet for this effort as the Gliders. Two manuscripts are under-preparation. The glider data is being used to validate numerical model water mass tracking. A second manuscript is focused on the physical forcing of the optical properties in these waters.